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COLD REGIONS AND OFFSHORE TECHNOLOGY RESEARCH

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August 27, 1985.

Dr. G. Cox,
U.S. Army Corps of Engineers,
Cold Regions and Engineering Laboratory,
72 Lyme Road,
Hanover, New Hampshire,
03755.

Dear Gordon;

Re: Ice Investigation Around a Caisson Island in the Beaufort Sea (Contract DACA89-85-M-1684)

I thought it was time I dropped you a note describing the status of this project.

Currently, I am reviewing the data which was collected, and I am in the process of writing the final report.

Like many field studies, the project did not proceed exactly as we had originally proposed, and in hindsight we would have done some things differently. However, the final outcome is that we did obtain some useful data which adds to our total knowledge base of how ice acts on arctic structures surrounded by stable rubble fields. (Although the results obtained have not revealed any new spectacular findings.)

As you know, the original objectives of the program were to see how ice pressure sensors in the ice compared with the load cells on the structure; and also to gain a better appreciation of typical loads acting on rubble fields and the amount of load transmitted through the rubble to the structure. As you also know the original plan was to do the work at the Gulf Molliqpak. But the ice there never did stabilize, nor did a rubble field form. Fortunately (as you also know) I had arranged a contingency plan to do the work at the Esso CRI, and that is where the study was performed. The Amerk location was in 26m of water at the very edge of the normal landfast ice limit - see Figure 1.

The combination of late funding; waiting to see if the ice would stabilize around the Molliqpak; and the necessity to wait for accommodation at the CRI, led to the field installation not commencing until February 21, 1985. By this time there was a fairly large grounded rubble field around the CRI (see Figures 2 and 3).

Nevertheless I was optimistic that the study objectives could still be met, and I had been able to squeeze into the project budget a total of seven ice pressure sensors (compared to the original four described in the letter of contract of February 4, 1985). Also, because of the additional funding from CRREL I knew that I could continue monitoring through May if conditions permitted. Furthermore, although the ice rubble appeared to be well grounded, the ice around Amerk was still quite mobile (except to the south). I felt therefore that there was still a good chance of major ice loading events occuring causing ice loads to be transmitted through the consolidated layer in the rubble to the CRI.

An immediate dilemma on arriving at the site was the question of where to deploy the sensors. The North and N.E. caissons are the most heavily instrumented (see Figure 4). Prior to arrival at the site, a review of rubble field features (see Figure 3) suggested a possible deployment of most of the sensros in a sector off the N.E. caisson where the rubble appeared to be low.

However, closer inspection of the rubble indicated virtually no flat spots off the N.E. caisson. Furthermore, the very high grounded rubble at the perimeter (10-15m) gave us concern that ice loads transmitted through to the caisson might be negligible. On the other hand, there were several flat spots in the rubble off the S.E. caisson. Furthermore, although the perimeter rubble was also high, it was expected that in the spring, loads from the south due to thermal expansion of the landfast ice might be significant. Therefore, the S.E. was the area chosen for the deployment of most of the sensors, see Figure 5.

The exceptions were as follows:

- Sensor 1 (an Arctec Hexpack) was deployed off the N.E. caisson in a "flat spot" opposite a "shear-bar" load cell on the caisson. This location was the only "flat spot" off the N.E. caisson and some removal of ice blocks was necessary in order to enlarge the flat area prior to sensor installation. A major rationale for installing this sensor was that none of the other caissons on the east or south side had operational shear-bar load cells.
- Sensor 7 (an Exxon panel) was deployed close to the south edge of the rubble in an area which appeared to be ungrounded. It was hoped that this sensor would record typical ice loads imposed by the ice at the edge of the rubble field (prior to any absorption of load by grounded features). Ideally this sensor should have been installed at the S.E. edge of the rubble along a radial line from the inner sensors. However no suitable location could be found in the S.E. sector (the edge of the rubble was too steep). Conversely one of the inner sensors should have been placed on a line between sensor 7 and the south caisson. But, no suitable location in the rubble on the south side could be found (primarily because flaring it disturbed the ice).

As already mentioned five sensors were deployed in the ice off the S.E. caisson (Figure 5). Three sensors of different types (Hexpack, Ideal and CMEL Mark IV) were installed close to the load instrumentation at the north end of the S.E. caisson. Another Hexpack was placed about 20m further out on the same radial line. For comparison an Exxon panel was placed a similar distance out from the caisson but further south.

The locations chosen were all in relatively flat areas but installation was not easy. Air temperatures were in the range -30 to -35°C during the period and equipment such as chain saws didn't work too well. Also the thickness of the consolidated zone was generally greater than 2m, so installation of the long panel sensors required removal of a lot of ice. Because of chain saw problems most panels were installed using auger and chisel. This required the mining of about 3 tons of ice per installation. Some panels were not installed to their full depth because of these difficulties. In addition to equipment problems we were also plagued with polar bears; their presence prevented us from working outside the caissons on several occasions.

We also had problems with our data acquisition system. This was an Arctec Arcdats system rented for the project. It consisted of a slave unit on the ice which was hardwired to a master recording unit installed in one of the heated control rooms on caisson 3. Although both units appeared to be functioning prior to shipment from Calgary, our technician had problems trying to set-up the system in the North. We finally had to bring the slave unit out for checking by Arctec; they replaced several faulty components.

All this of course took time, so that we didn't actually get the system operating properly until March 20. We demobilized during the period May 13 to 17, but some minor melt pool flooding caused the system to malfunction on about May 5, 1985.

In addition to the d.a. problems, two sensors malfunctioned, the CMEL Mark IV biaxial sensor and the Weir-Jones Ideal panel. After installation the balance points seemed to drift randomly. It was later found that the Ideal panel had a leak.

The other five sensors all appeared to function satisfactorily.

As expected, the sensor near to the rubble edge recorded the most ice pressure activity, although no event seems higher than about 200 kPa. Figure 6 shows some typical output. The results appear to be quite plausible. The Exxon sensor nearer to the caissons recorded very low to negligible ice pressure events. The Arctec Hexpacks show some activity at the various levels through the ice (see typically Figure 7). However these results need to be reviewed carefully before jumping to any conclusions, and this is what I am currently engaged in.

I am also looking at the Esso records of loads on the caissons for the same period. At first glance it appears that only very small ice forces were experienced by the caissons.

In addition to the ice sensors, eight survey posts with reflectors were installed on the ice rubble. It appears that between February 24 and May 13 negligible lateral movements occured within the grounded rubble.

Aerial stereo photographs of the rubble have been taken and I am getting these processed in order to establish rubble heights and profiles along one or two radial lines. This information will be combined with the berm bathymetry chart to estimate how much of the rubble field was grounded.

I hope to get the final report completed within the next few weeks.

If you have any immediate comments, questions or suggestions please give me a call.

With best wishes.

Yours sincerely,

Ken Croasdale

K. R. Croasdale P. Eng.

KRC/am

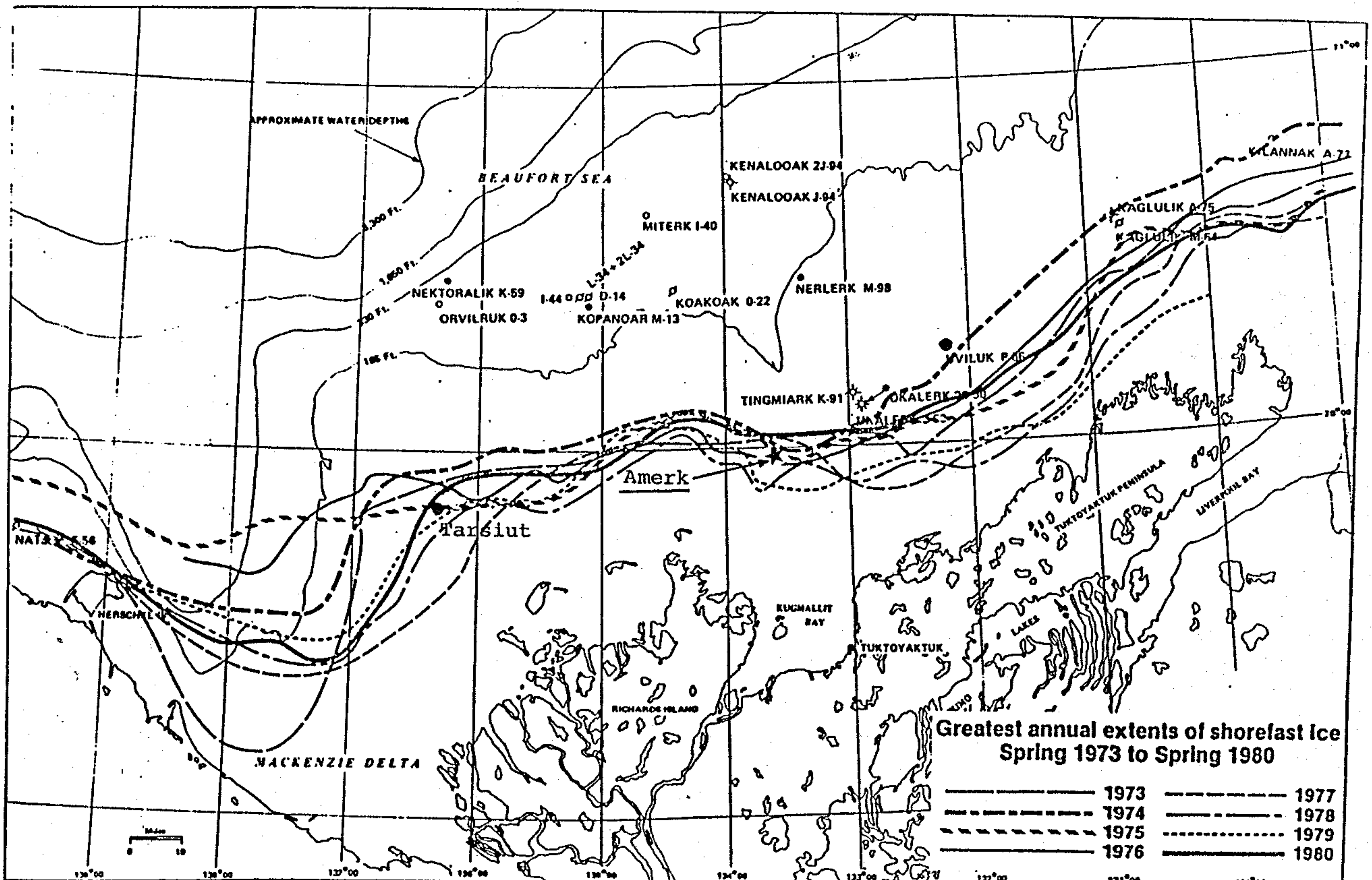
Greatest annual extents of shorefast Ice
Spring 1973 to Spring 1980
1973
1974
1975
1976
1977
1978
1979
1980
BEAUFORT SEA
APPROXIMATE WATER DEPTHS
MACKENZIE DELTA
KENALOOAK 2J-94
KENALOOAK J-94
MITERK I-40
NEKTORALIK K-59
ORVILRUK O-3
I-44
D-14
L-34 + 2L-34
KOPANOAR M-13
KOAKOAK O-22
NERLERK M-98
TINGMIARK K-91
OKALERK
KAGLULIK A-75
KILANNAK A-72
Amerk
Tarsiut
HERSCHEL IS.
RICHARDS ISLAND
KUGMALLIT BAY
TUKTOYAKTUK
TUKTOYAKTUK PENINSULA
LIVERPOOL BAY
LAKES
1,000 Ft.
300 Ft.
100 Ft.

FIGURE 1

ICE & RUBBLE CONDITIONS
AMERK O-Ø9 85/01/30

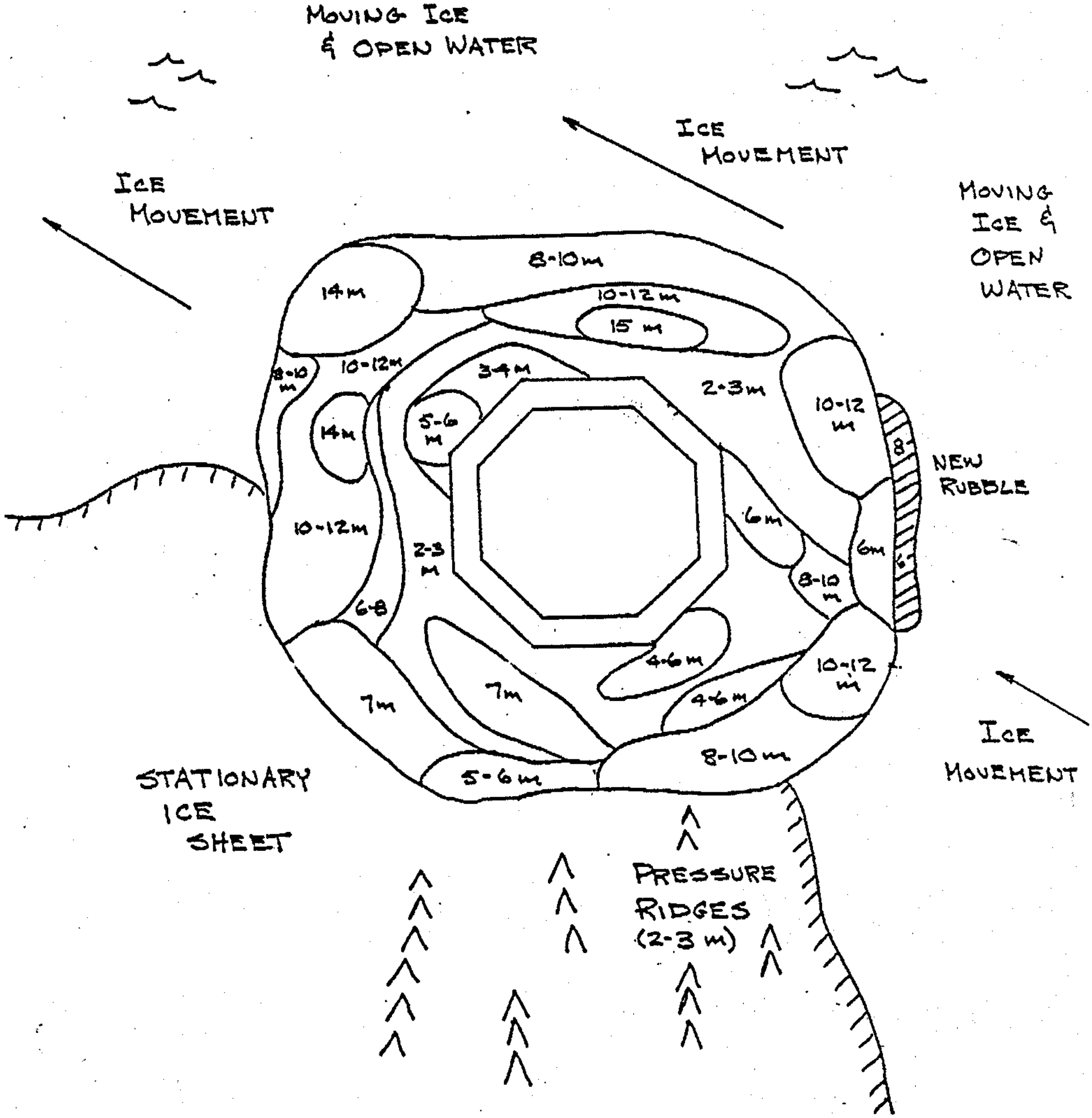

FIGURE 2

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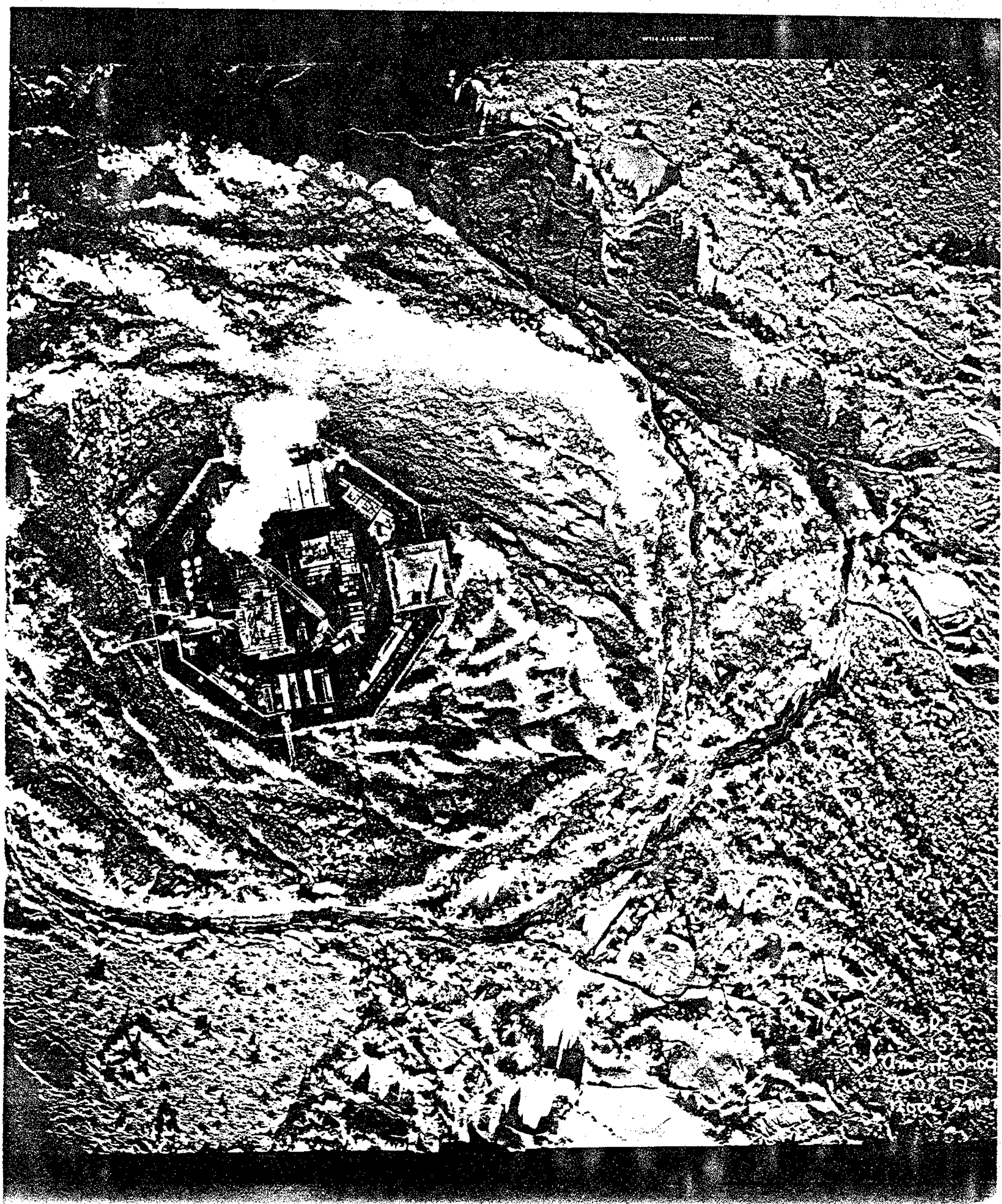
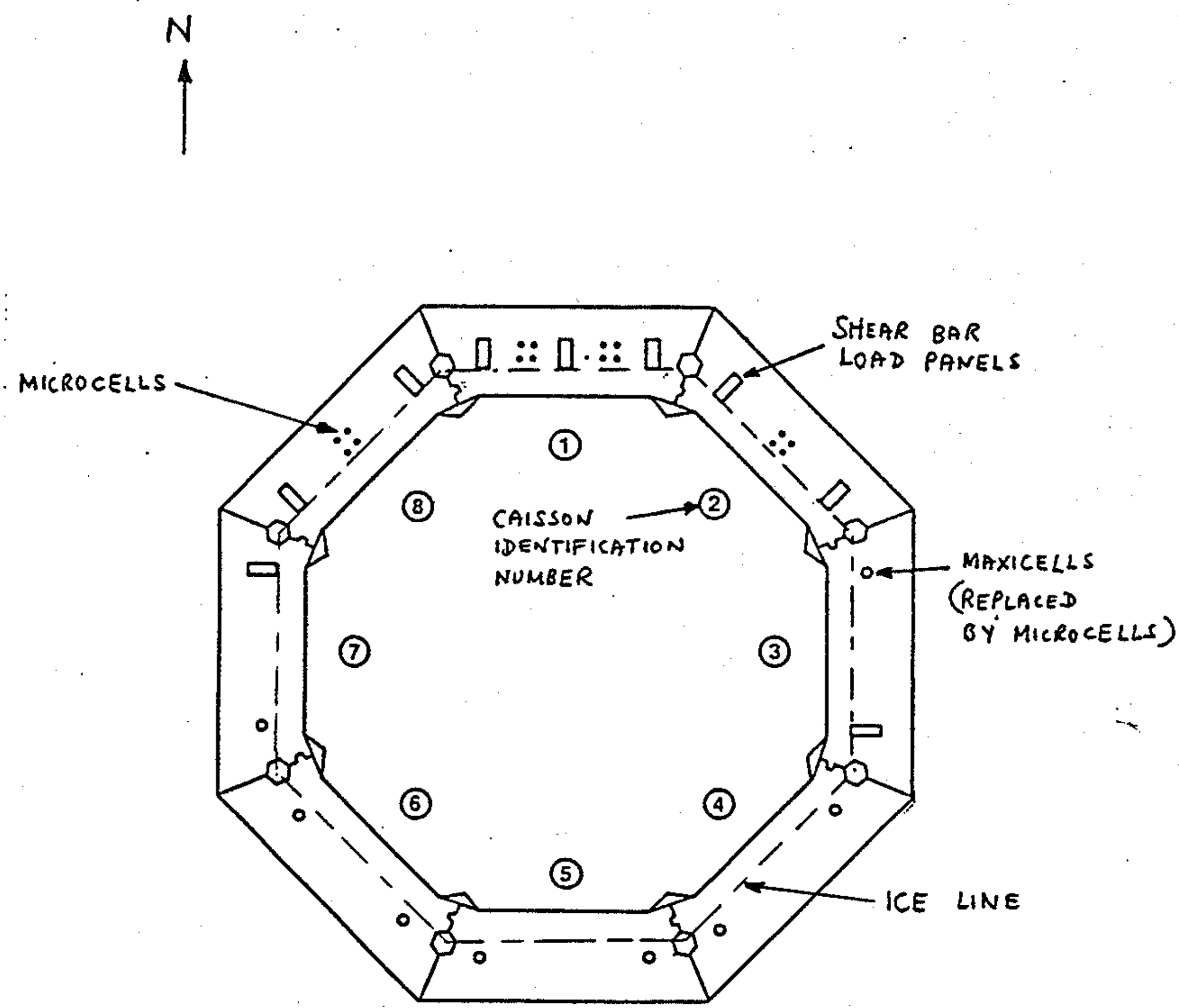
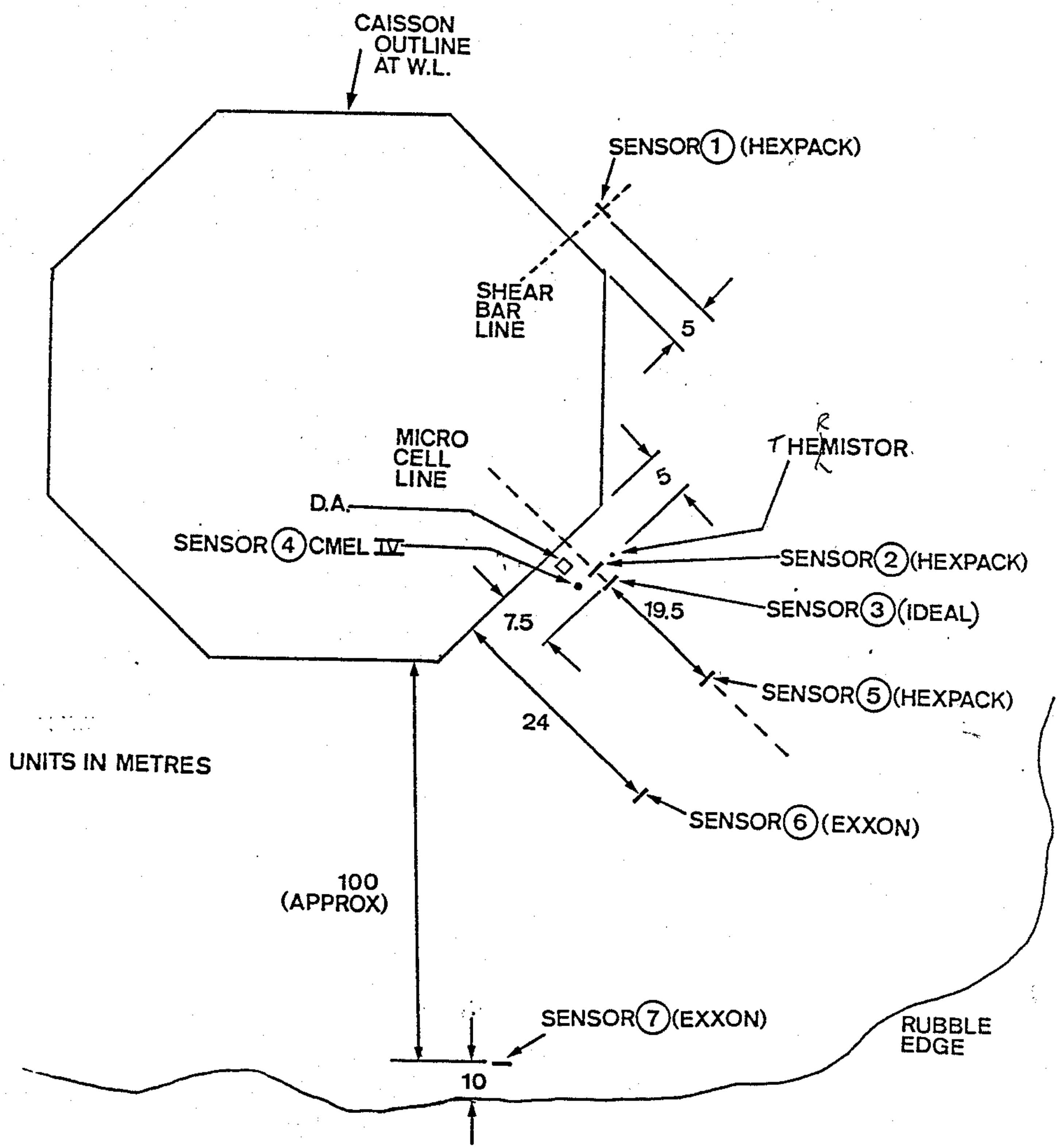
FIGURE 3





ESSO CRI ICE LOAD SENSORS

FIGURE 4



SENSOR LOCATION AND IDENTIFICATION NUMBERS

Figure 5

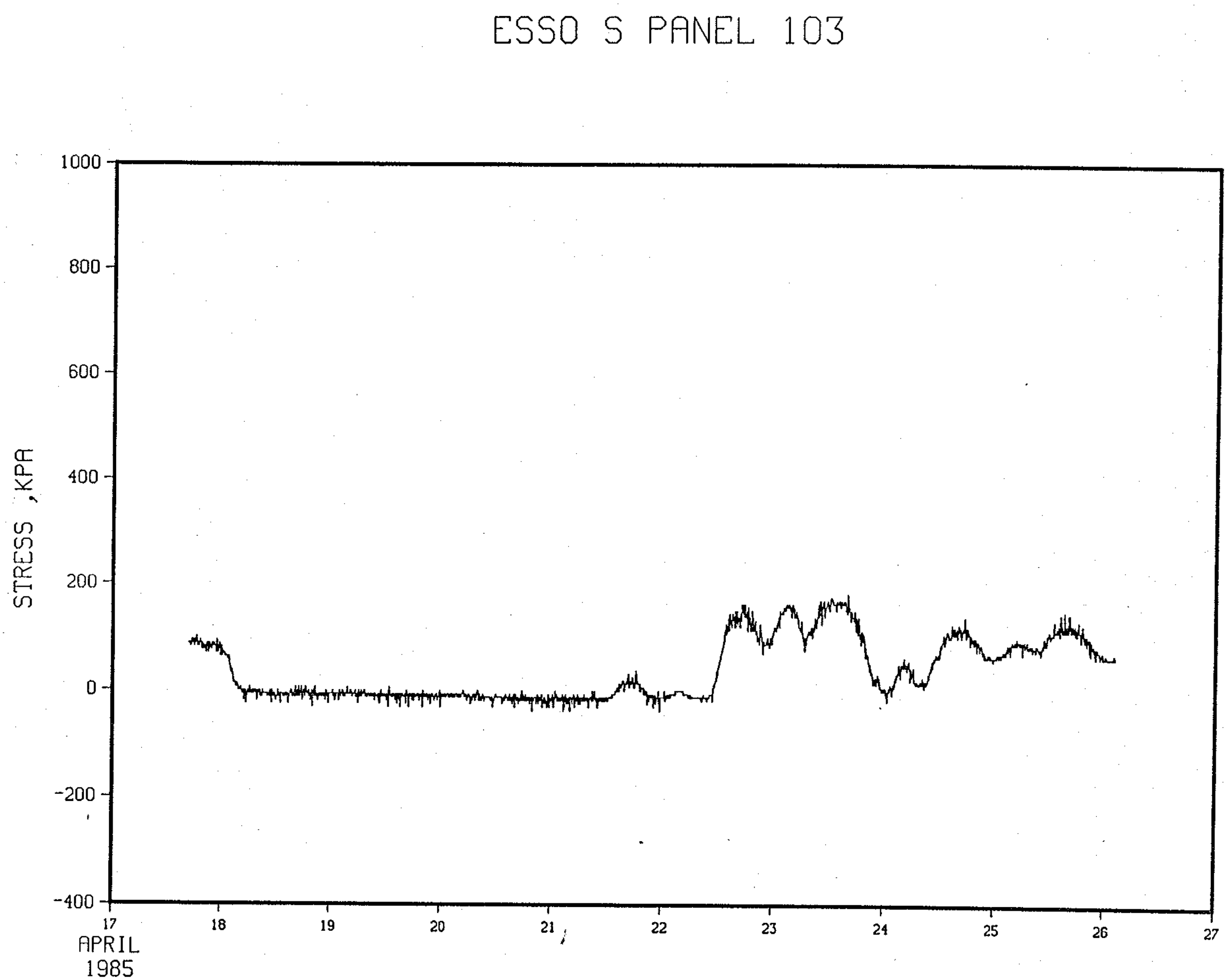

ESSO S PANEL 103
STRESS ,KPA
1000
800
600
400
200
0
-200
-400
17
APRIL
1985
18
19
20
21
22
23
24
25
26
27

FIGURE 6

HEX PANEL 105

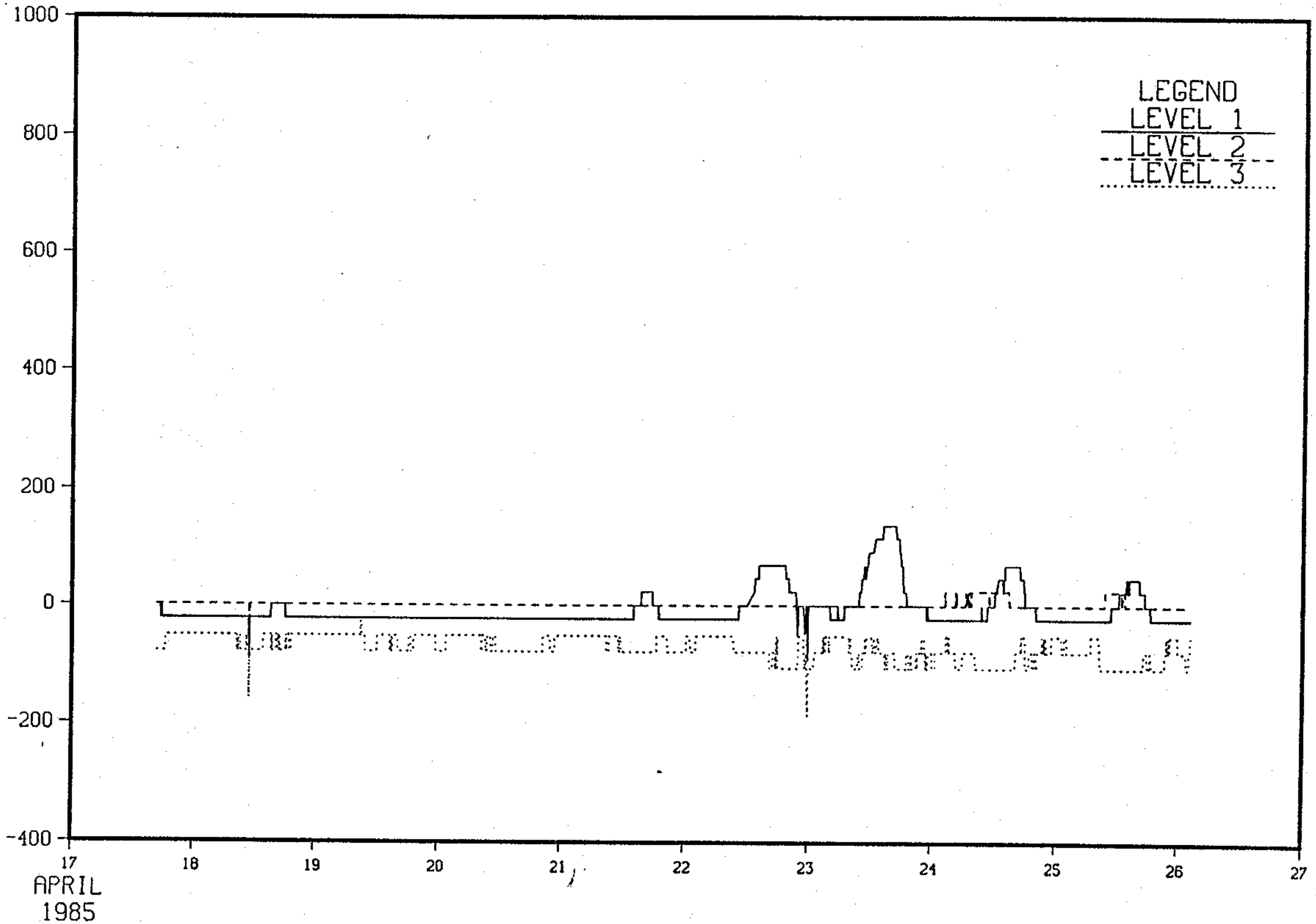


FIGURE 7